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Dose Evaluation According to Depth Variation during MVCT Imaging

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1. Introduction

Recent advancements in imaging devices and radiation therapy equipment have led to various radiation treatments. Particularly, Image Guided Radiation Therapy (IGRT) has significantly improved the accuracy of radiation therapy by comparing reconstructed images of the patient's anatomy based on simulated treatment with the patient's position before treatment [1]. In the past, IGRT was conducted using Electronic Portal Imaging Devices (EPID) and 2D imaging. Recently, Tomotherapy, which integrates linear accelerators with computed tomography (CT) scanners (Hi-Art System, Accuray, USA), has been introduced. Tomotherapy enables more precise reproduction of the patient's position through 3D imaging with Mega-voltage Computed Tomography (MVCT) [2]. However, during the process of acquiring images necessary for Image Guided Radiation Therapy, patients are exposed to radiation. Especially, Tomotherapy uses 3.5MV high-energy X-rays to acquire MVCT images, and the resulting radiation exposure cannot be ignored. Therefore, in this study, we aim to evaluate the radiological safety through depth-specific MVCT dose assessment according to the imaging conditions.

2. Experimental Equipment and Method

2.1 Experimental Equipment

The dosimeter used in the experiment was a glass dosimeter (GD-352M, AGC Techno Glass). Glass dosimeters are widely used for dose assessment due to their simple handling and reading process, excellent inter-component reproducibility, and low energy dependence on photon radiation [3].

The phantom used to evaluate the dose distribution according to depth was the Cheese phantom. The Cheese phantom is a cylindrical solid water phantom with a diameter of 30 cm and a length of 18 cm, which can be separated into two hemicylinders. It allows for both relative dose evaluation using film at the center of the circle and absolute dose evaluation using an ion chamber simultaneously. On the opposite side, it contains 20 plugs for obtaining Hounsfield Units (HU) values of CT density and is used for image calibration [4].

2.2 Experimental Method

Table 1 illustrates the imaging conditions of MVCT. MVCT has three shooting conditions: Fine, Normal, and Coarse, where Fine corresponds to a 1 mm pitch, Normal to a 2 mm pitch, and Coarse to a 3 mm pitch. Fine, Normal, and Coarse are scanned at 2, 4, and 6 mm slice thickness, respectively.

Table 1 MVCT imaging conditions

	Imaging conditions
Fine	Fine = 2 mm slice thickness, 1 mm pitch
Normal	Normal = 4 mm slice thickness, 2 mm pitch
Coarse	Coarse = 6 mm slice thickness, 3 mm pitch

For the dose measurements according to depth, as depicted in Figure 1, thirteen glass dosimeters were inserted into holes made at 1 cm intervals from the surface to the center point of the Cheese phantom. Subsequently, solid water sticks shaped like pencils were inserted, and the phantom was scanned. The holes were sequentially numbered from the surface to the center. Thirteen glass dosimeters were inserted, and measurements were repeated five times for each imaging condition to assess the average values.

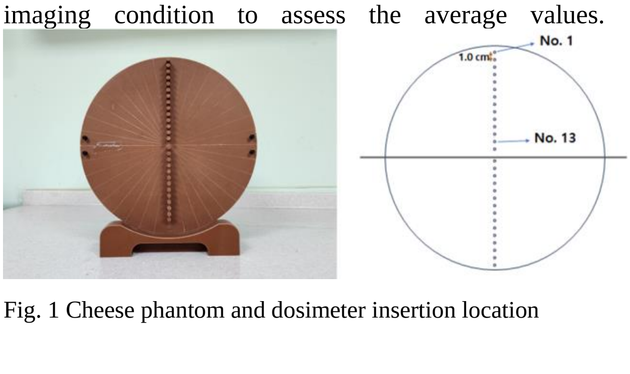

Fig. 1 Cheese phantom and dosimeter insertion location

3. Experimental Results and Analysis

Figure 2 presents the graph depicting the average measurements of the Cheese phantom according to depth variation under the Fine imaging conditions. At position 1, the highest measurement was recorded at

21.56±0.47 mGy, while at position 8, the lowest measurement was observed at 19.76±0.41 mGy. The central position, number 13, yielded a measurement of 20.18±0.36 mGy.

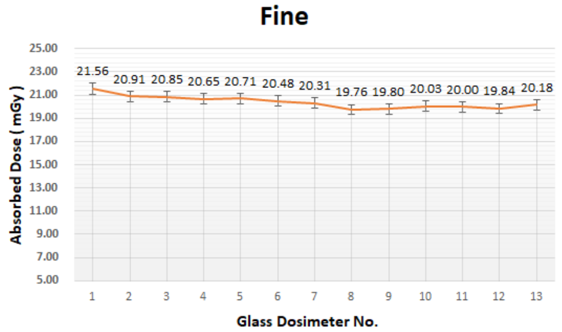

Fig. 2 Fine shooting conditions result

Figure 3 illustrates the graph depicting the average measurements of the Cheese phantom according to depth variation under the Normal imaging conditions. At position 2, the highest measurement was recorded at 10.99±0.58 mGy, while at position 10, the lowest measurement was observed at 9.76±0.14 mGy. The central position, number 13, yielded a measurement of 9.97±0.23 mGy.

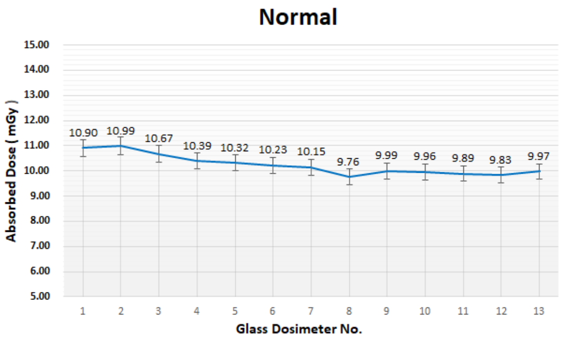

Fig. 3 Normal shooting conditions result

Figure 4 depicts the graph illustrating the average measurements of the Cheese phantom according to depth variation under the Coarse imaging conditions. At position 1, the highest measurement was recorded at 7.54±0.58 mGy, while at positions 11 and the central position, number 13, the lowest measurements were observed at 6.50±0.05 mGy.

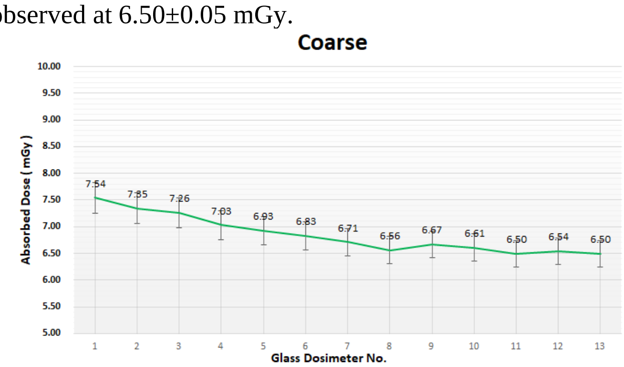

Fig. 4 Coarse shooting conditions result

Scan time were 521 seconds for Fine, 271 seconds for Normal, and 186 seconds for Coarse. Exposure doses were measured to be highest under the Fine condition, followed by Normal and then Coarse, indicating differences in slice thickness due to pitch value selection and resulting variations in scan time..

4. Conclusions

This study aimed to evaluate the radiological safety through dose assessment of MVCT, an essential component of Image Guided Radiation Therapy (IGRT), which is commonly used in recent radiation therapy practices. The results ranged from a minimum of 6.50 mGy to a maximum of 21.56 mGy per single exposure. Since the exposure dose increases with the number of treatments, it is essential to consider probabilistic effects. Therefore, radiation workers should be aware of this and strive to maintain exposure doses to patients as low as reasonably achievable (ALARA) by considering factors such as the number of re-examinations, frequency, and imaging conditions.

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